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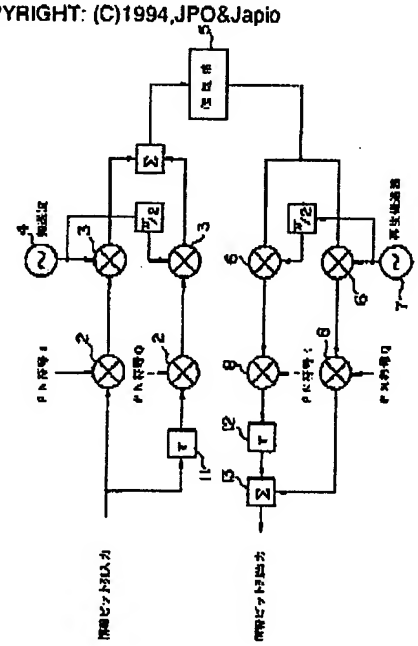
# (54) SPREAD TIME DIVERSITY SPECTRUM COMMUNICATION SYSTEM

(57) Abstract:

PURPOSE: To distribute an error in a small processing delay time and to improve a transmission characteristic by distributing an information bit to (n) system signals, giving each different delay thereto, thereafter, modulating, synthesizing and transmitting them, and executing same reverse processing in a reception side.

CONSTITUTION: An information bit is distributed to (n) system signals of two systems, etc., and a delay $\tau$ is imparted thereto through each different delay '0' and a delaying circuit 11. Thereafter, each information bit of two diffused and modulated, and modulated by diffusing circuit 2, and modulating circuit 3, respectively, and also, synthesized on a time base by a synthesizer and transmitted to a transmission line 5. In a reception side, after executing corresponding demodulation/reverse diffusion, etc., the delay time difference of an information bit train of each system is compensated, thereafter, it is synthesized or selected. By separating timewise this one information bit and distributing and transmitting it, an error is distributed in a small processing delay time, and a transmission characteristic in a burst error is improved.





(Translation)

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[Scope of Claim for Patent]
[Claim 1]

A time diversity spread-spectrum communication system performing communication by applying spreading modulation to an information bit sequence, which is to be transmitted, with a known code sequence of a higher rate than the information bit sequence, characterized in that

a transmitter divides one bit of the transmission information bit sequence into information bits of n sequences ($n \geq 2$; n is a natural number);

provides a time difference with each of the information bit sequences by means of a delay element, then divides the n information bit sequences into k sets of m bit information ($n = k\ m$; k, m are natural numbers);

applies the spreading modulation to them with the known high-speed code sequence and $2^m$ level modulation with k carrier waves ($n \geq m \geq 1$); and

multiplexes all of the modulated waves into a time-series signal to transmit it; and

a receiver performs demodulation and despreading processes corresponding to those of the transmitter; corrects the delay time differences between the n information bit sequences by the use of delay means; and combines or selects the results thereof.

[Claim 2]

The time diversity spread-spectrum communication system according to claim 1, wherein n known high-speed code sequences are provided.

[Claim 3]

The time diversity spread-spectrum communication system according to claim 1, wherein only one known high-speed code sequence is provided, is subjected to a code-phase change and is applied to

the process for each sequence.

[Claim 4]

The time diversity spread-spectrum communication system according to claim 1, characterized by comprising means for detecting fluctuation period information on a communication path, and by controlling the delay time differences between the n information bit sequences in accordance with the fluctuation period information on the communication path so that they are not coincident with the fluctuation period.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

This invention relates to a spread-spectrum communication system.

[0002]

[Prior Art]

Conventionally, when a spread-spectrum communication is used for a time variant communication path of, for example, fading or shadowing, which is seen in a mobile communication, a mobile satellite communication or the like, block interleave technique has been used so as to alleviate degradation due to errors occurring contemporaneously (burst errors). In addition, the binary phase shift keying (BPSK) has been used for the modulation of information bits.

[0003]

However, the conventional method for carrying out the block-interleave technique on a serial information sequence to produce serial information bit sequences performs the rearrangement of information blocks only after reception of all of them and outputs the results. Therefore, sufficient randomization on the burst errors requires long process delay time. In addition, the interleave method is a mere rearrangement of bits and, when attention is directed to each bit, there is no dispersing effect of errors.

[0004]

In Fig. 6, one example of a conventional spread-spectrum communication system is illustrated. The information bit sequences to be transmitted are input into a block interleave circuit to carry out the rearrangement of bits and are spread with a known high-speed

spreading code (for example, a PN code). The results ant signals are input into a binary phase modulator, and the modulation output is transmitted. The receiver uses its functions corresponding to the transmitter's ones to reproduce reception information bit sequences.

[0005]

[Problems to be Solved by the Invention]

It is an object of the present invention to improve transmission characteristics on the use of a spread-spectrum communication for the time variant communication path of fading, shadowing or the like, by randomizing the burst errors within a short process delay time and by dispersing errors for each bit.

[0006]

[Means by which the problems are solved]

According to the present invention, the information bits to be transmitted are divided into n signals, are provided with the respective delay times different from each other (time delay "0" is also included therein), and are then modulated and transmitted. The receiver corrects the respective delay times thereof and multiplexes or selects n-divided information bits.

[0007]

[Mode of Operation]

Since the process delay time according to this invention is only a delay time provided by the transmitter, short process delay time can be realized in comparison with the conventional block interleave technique.

[0008]

In addition, since one bit information is divided into n sequences and then transmitted, dispersing effect of errors for each bit can be obtained.

[0009]

[Embodiment of the Invention]

An embodiment according to the present invention will be explained. Fig. 1 is a block diagram of this embodiment, and shows a case of $n = 2$ and $m = 2$. An information bit sequence to be transmitted is divided into two sequences, and a time difference is given therebetween by a delay circuit. After that, they are spread with the high-speed code sequences (PN codes I and Q) and are subjected

to four-level phase modulation (quadrature modulation) and are then transmitted. Fig. 2 shows the original information bit sequences and two divided signals with the time difference $\tau$ provided therebetween. For example, if $\tau$ is 10, the time difference between the I channel and Q channel is 10 bits, and the Q channel for $I_0$ as the information bit of the I channel is $I_0 - \tau$ = I-10 (a 10 bits-previous information bit). Thus, four-level phase modulation is carried out. The receiver carries out demodulation and despread processes by the use of functions corresponding to those of the transmitter, corrects the delay time difference and multiplexes the results thereof so that a reception information bit sequence is obtained. The demodulation may be four-level phase demodulation (quadrature demodulation) or a combination of discrete PN code synchronizers and binary phase demodulators.

[0010]

Referring to Fig. 2, a second embodiment will be explained. Fig. 3 is a block diagram of a transmission section of this embodiment and shows a case of $\underline{n}$ = 2 and $\underline{m}$ = 2. An information bit sequence to be transmitted is divided into two sequences, and a time difference is given therebetween by a delay circuit. After that, they are spread with the high-speed code sequences (PN codes I and I$\tau$ ode) which have the same pattern but have different code phases. Thus, they are subjected to four-level phase modulation and are then transmitted. The receiver carries out demodulation and despreading processes by the use of functions corresponding to those of the transmitter, corrects the delay time difference and multiplexes the results thereof so that a reception information bit sequence is obtained. The demodulation may be four-level phase demodulation (quadrature demodulation) or a combination of discrete PN code synchronizers and binary phase demodulators.

[0011]

The same results can be obtained even if the order of spreading and modulation processes and/or the order of despreading and demodulation processes are reversed in the above-mentioned embodiments.

[0012]

In Fig. 5, a third embodiment is shown. In addition to the

above-mentioned embodiments, the receiver according to the present embodiment has a communication path fluctuation period detector comprising reception signal envelope detector and so on, and a delay amount information producing circuit and a delay amount information transmission line. The present embodiment controls the delay amount in the time diversity process so that it is not coincident with the period of degradation of the communication path such as a fading pitch. The above structure can prevent the simultaneous degradation of the simultaneously transmitted information bits according to the time diversity so that the present embodiment can obtain more diversity effects.

[0013]

[Effect of the Invention]

As it has the above-mentioned structure, one information bit can be transmitted more than one separately from each other so that the dispersion effect of bitwise errors can be realized under a shorter process delay time.

[0014]

As an example of advantageous effect of the present invention, Fig. 4 shows a result obtained by comparison between the conventional block interleave-based approach and the present invention ($\underline{n}$ = 2, $\underline{m}$ = 2) as to their code error rate characteristics under Rayleigh fading conditions (Doppler frequency 200, 100 or 50Hz). The study was made about the case where: the information bit rate was 10 kbps; the spread spectrum coefficient was 128; error correction was not performed; and the demodulation method was the delay detection method. As apparent from the drawing, a great improvement (five to seven dB at an error rate of $10^{-2}$) can be obtained according to the present invention.

[Brief Description of the Drawings]

Fig. 1 is a block diagram of one embodiment ($\underline{n}$ = 2, $\underline{m}$ = 2) of the present invention.

Fig. 2 shows information bit sequences in the present invention.

Fig. 3 is a block diagram of another embodiment ($\underline{n}$ = 2, $\underline{m}$ = 2) of the present invention.

Fig. 4 is a view showing the effect of the present invention.

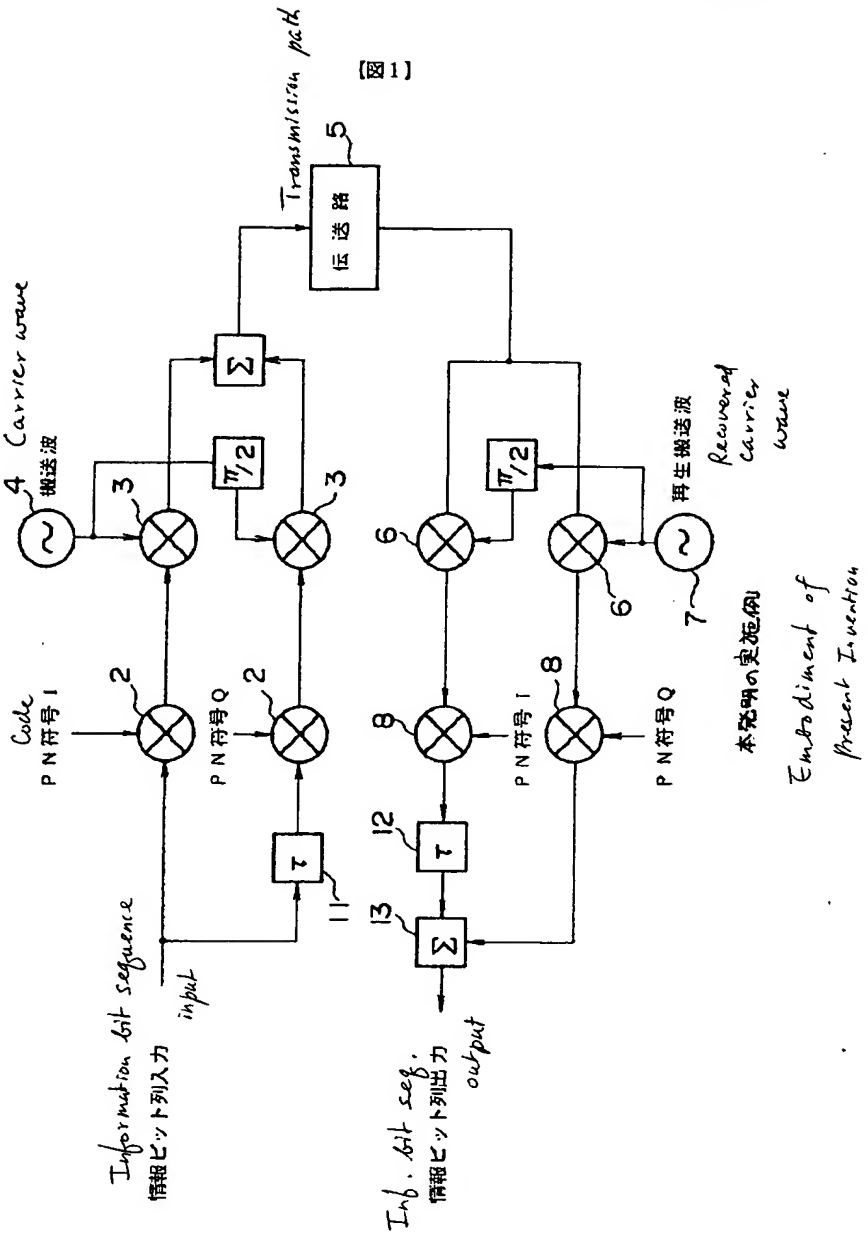
Fig. 5 is a block diagram of still another embodiment of the present invention.

Fig. 6 is a block diagram of a conventional spread-spectrum communication system using the block interleave approach.

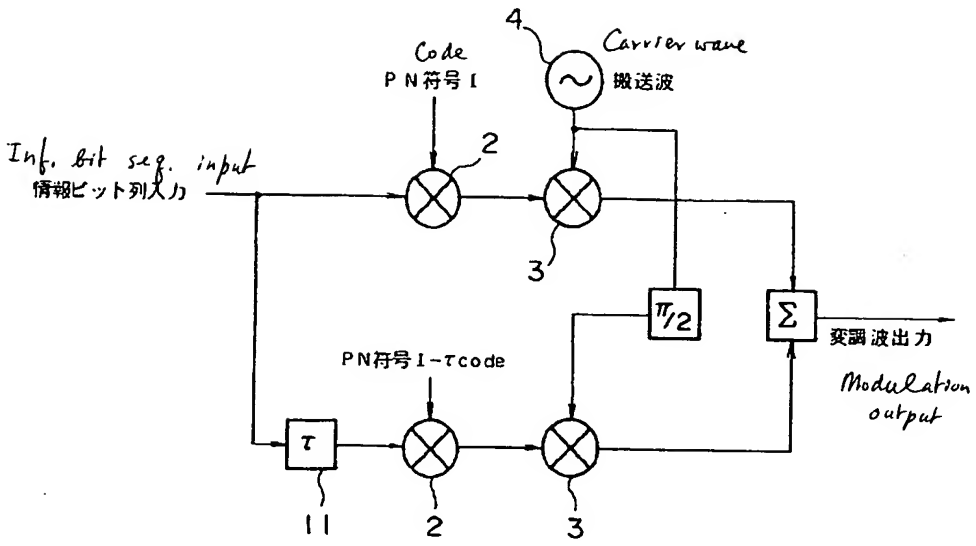
[Description of Reference Numerals]

1 denotes block interleave circuit; 2, spread circuit; 3, modulation circuit; 4, carrier wave; 5, transmission line; 6, demodulator circuit; 7, reproduced carrier wave; 8, despread circuit; 9, blocked interleave circuit; 11, delay circuit; 12, delay circuit; 13, multiplexing circuit; 21, communication path fluctuation period detector; 22, delay amount information producing circuit; and 23, delay amount information transmission line.

【図1】

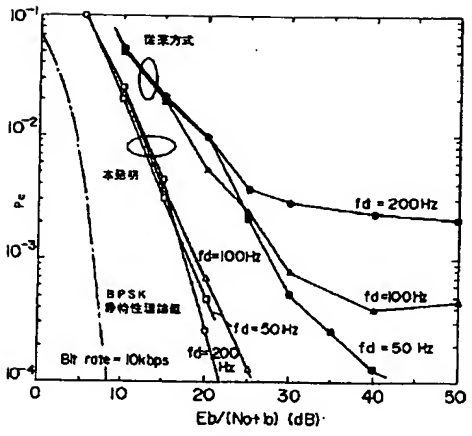

Transmission path
伝送路
5
Carrier wave
搬送波
4
3
π/2
Σ
Code
PN符号I
PN符号Q
2
τ
11
Information bit sequence
情報ビット列入力
input
Inf. bit seq.
情報ビット列出力
output
12
13
6
8
再生搬送波
Recovered carrier wave
7
本発明の実施例
Embodiment of Present Invention

【図3】

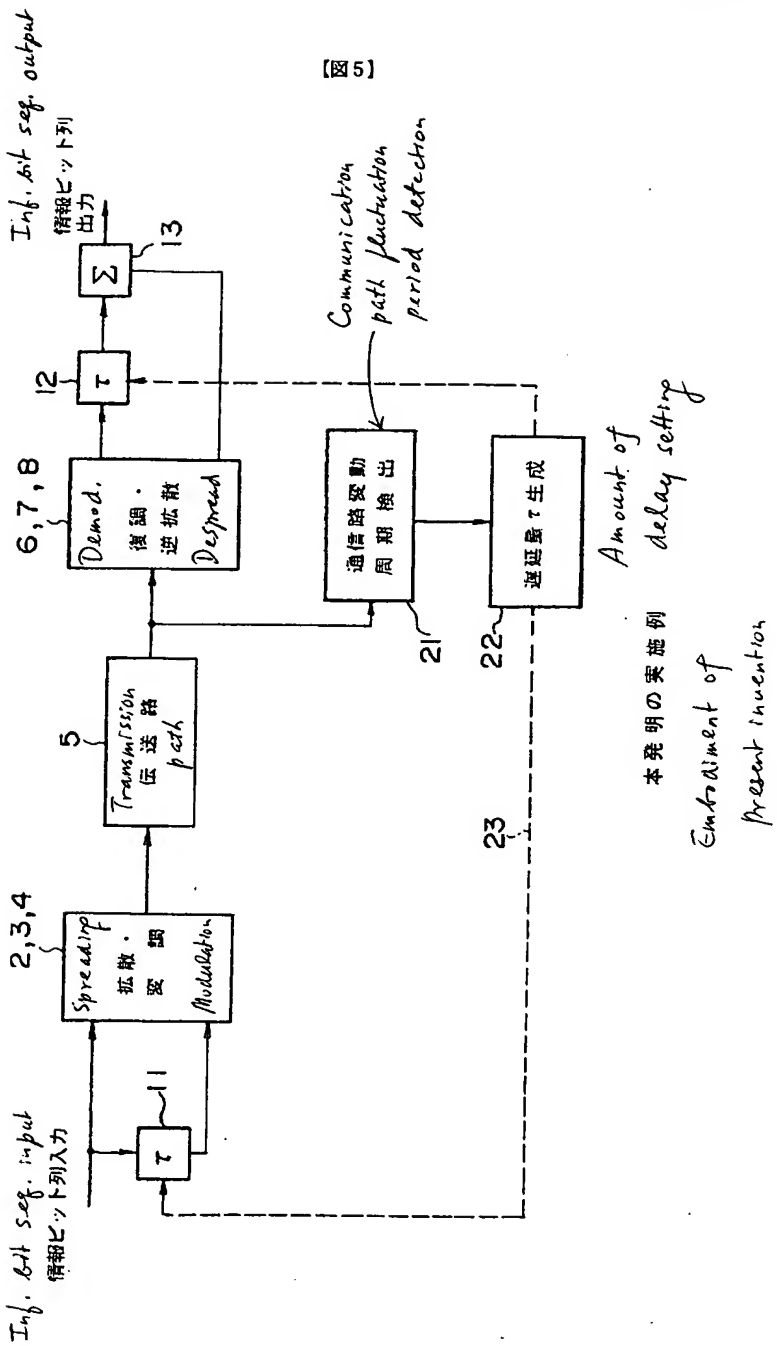



本発明の実施例
Embodiment of Present Invention

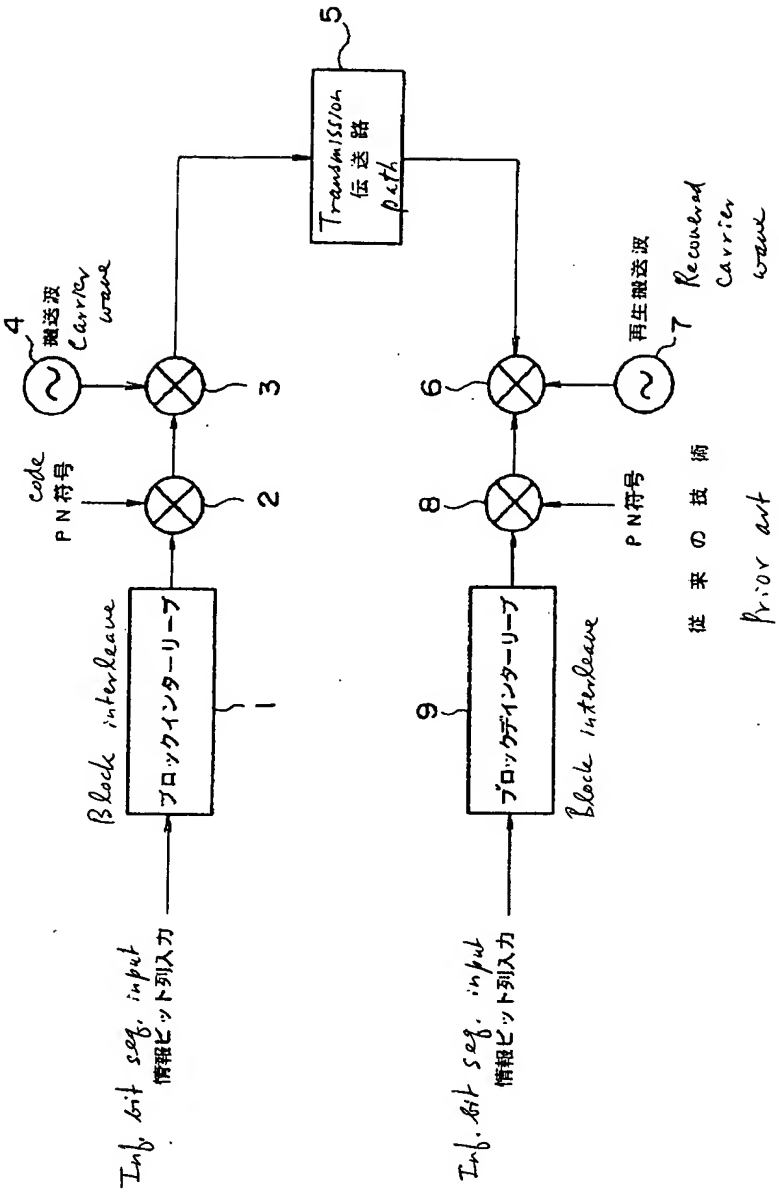
【図4】



【図5】


Inf. bit seq. output
情報ビット列出力
Σ
13
12
τ
Communication path fluctuation period detection
6,7,8
Demod. 復調・逆拡散 Despread
通信路変動周期検出
21
遅延量τ生成
22
Amount of delay setting
本発明の実施例
Embodiment of present invention
5
Transmission 伝送路 path
23
2,3,4
Spreading 拡散・変調 Modulation
11
τ
Inf. bit seq. input
情報ビット列入力

【図6】


Info. bit seq. input
情報ビット列入力
Block interleave
ブロックインターリーブ
1
code
PN符号
2
3
4
搬送波
Carrier wave
5
Transmission
伝送路
path
6
8
PN符号
7
再生搬送波
Recovered Carrier wave
9
ブロックデインターリーブ
Block interleave
Info. bit seq. input
情報ビット列入力
従来の技術
Prior art